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10/010778

SE 00 / 1416

REC'D 17 AUG 2000

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(21) Patentansökningsnummer 9902574-4  
Patent application number

(86) Ingivningsdatum 1999-07-05  
Date of filing

Stockholm, 2000-08-09

För Patent- och registreringsverket  
For the Patent- and Registration Office

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# FIXTURING SYSTEM FOR PVD COATING OF CUTTING INSERTS

## BACKGROUND OF THE INVENTION

5 The present invention relates to a PVD (Physical Vapour Deposition) batch fixturing system for cutting inserts, suitable for rational large scale production and allowing for fully automatic loading.

Physical Vapour Deposition of wear resistant hard coatings on cemented carbide cutting inserts has been in industrial use for more than 15 years and the practice of the PVD method is still increasing as is the number and variety of products subjected to this process.

10 The PVD process is, in contrast to CVD (Chemical Vapour Deposition), a line-of-sight process with limited ability to achieve an equal coating thickness around a three-dimensional body such as a cutting insert. This fact requires special arrangements for the fixturing system; the cutting edges of the individual cemented carbide cutting insert as well as the cutting edges of all the inserts in the entire batch must be as equally exposed to the flux of the coating material as possible. Preferably, the largest coating thickness is to be found on that part of the insert where it is most required for the particular cutting operation to be carried out. Furthermore, the rake face and the clearance face of the insert must both be subjected to the least possible effect of shadowing from the surrounding cutting inserts. These requirements may lead to a low loading density of inserts if not specifically designed loading fixtures are being used. A further complication is introduced when the cutting inserts do not possess any holes in the centre enabling hanging them on an arrangement of hooks.

25 There are several methods for loading inserts without holes available but two main principles can be distinguished:

- (i) locking the inserts in mechanical fixtures and keeping them in a desired position through e.g. slits or arms
- (ii) fixturing the inserts on magnetic holders allowing for the magnetic forces to keep the inserts in a fixed position during the deposition process.

30 The limitation of method (i), mechanically locking the inserts in fixed positions, is the risk that the locking device itself will shadow an area of the insert that should be coated. The shadowing effect may cause an undesired variation in the coating thickness or, in the worst case, areas that are almost without a coating. It is a disadvantage in cutting operations if the areas with thinner or absent coatings are located within the depth-of-cut area on the insert tool edge. The cosmetic appearance of the insert may also become undesirable with marks and fluctuations in colour that are not the same and alike on all the inserts.

40 The limitation of method (ii), magnetic holders, is the weight of the magnets which is significant. The high weight of the magnet assembly will restrict the functionality of the mechanism used to rotate the batch in the PVD coating chamber. The rotation is required in order to achieve as equal coating conditions as possible on all the material in the batch. The area of the insert, which is in contact with the magnet, will inevitably remain without a coating restricting the method to be best suited for inserts that may be allowed to have one side or one part of a side without a coating. Furthermore, one requirement of the inserts' geometrical shape would be that of a flat bottom surface to obtain a large enough contact area to the magnet in order to maximize the magnetic force keeping the inserts in place. The magnetic field strength decreases with increasing temperature and the typical PVD substrate temperature

range of 450-500°C, also puts specific requirements on the type of magnets that are to be used for this purpose..

5 A common practice in the prior art is to fixture the inserts side by side on a four- or six-folded pole. Each side of the pole having an area that allows several inserts to be placed in a two-dimensional pattern. This results in an unfavourable coating thickness distribution. As a consequence of the rotation of the pole, the clearance faces of the inserts placed along the vertical border of a face of the pole, will obtain thicker coatings than all the other clearance faces of the inserts placed on the same side of the pole. Furthermore, the parallel positioning of the inserts will cause a shadowing effect on the clearance faces of the inserts, causing a difference in coating thickness between the rake and clearance faces of the inserts. This difference is in certain cases most undesired in cutting operations.

## 15 OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a fixture system, especially suited for cutting inserts of a specific geometrical shape, of magnetic holders avoiding or alleviating the general limitations of a loading system based on the magnetic principle. Furthermore, it is an object of the invention to provide a loading system suitable for a rational production in larger scale.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a picture of the presently claimed invention.

25 Fig. 2 shows a schematic drawing of the presently claimed invention. The invention includes a metallic tube (A) encompassing a stack of alternating discs of magnets (B) and iron cores (C). A bar (D) passes through the centre of the magnets and iron cores. The bar is adapted to conform to the rotating construction in the PVD-equipment. The tube is further equipped with reinforcement rings (E).

30 Fig 3 and 4 display cross-sections of the invented construction with cemented carbide inserts loaded in with different loading densities.

## 35 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The batch loading system according to the present invention utilizes a tube manufactured of a non-magnetic metallic material, surrounding a stack of alternating discs of magnets and iron discs. The cutting inserts are placed on the outer wall of the solid tube and kept in place by the magnetic forces.

40 The physical shape of the outer tube in the present invention may be designed in a number of geometrical shapes. The cross-section of the tube may for instance be circular, elliptical, rectangular, quadratic, pentagonal, hexagonal and so on. In the description of the present invention only the circular cross-section will be described.

45 The circular shape of the fixture makes it specifically suited for loading inserts with a specific geometrical shape. The part of the insert in contact with the tube should preferably have an elongated geometry. One type of inserts that does not possess any central hole and has an elongated bottom surface that is not used in the cutting operation, and which requires an even coating thickness on the rake and the clearance faces, are inserts used for machining operations called parting and

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grooving. Inserts of this type and other types of inserts with similar qualities are especially suited for the present invention.

Fig. 3-4 show that the cylindrical shape of the tube leads to an improved exposure of the clearance faces in comparison to the inserts being positioned in parallel on a flat surface. The elongated bottom profile of the insert assures a firm contact with the tube. The tubular shape optimizes the ratio between surface area available for loading and volume of magnetic material. Thus, the weight of the fixture is minimized at the same time as the surface area of the fixture is maximized and a high loading density of inserts is allowed.

The arrangement of the magnets is important to the functionality of the loading system. The magnets are orientated with the north poles towards each other. In this way the magnetic field in the iron disc will be amplified and the effect of the magnets is used in an optimal way. The thickness of the magnetic discs in comparison with the thickness of the iron discs is also of importance. The iron disc must be thick enough to act as a buffer between the magnetic fields from the surrounding magnetic discs and thick enough to avoid saturation in magnetic flux. At the same time the iron disc has to be thin enough to avoid self-demagnetisation of the magnets.

The type of magnetic material being used is critical since many of the magnetic materials loose their magnetic properties at elevated temperatures. The material in the iron discs is preferably an iron material with a low content of alloying elements.

The metallic tube should be manufactured of a non-magnetic material, such as for instance stainless steel, in order not to disturb the magnetic flux from the magnetic discs to iron discs. The function of the metallic tube surrounding the magnets is primarily to protect the magnets from physical damage and from being coated. A coated surface will after a number of exposures to the coating process begin to loose particles of the coating. These particles will to a certain extent become attached to the inserts being coated at the time and will form defects on these inserts. Such defects may be detrimental to the performance properties of the insert if the defects are located in an area of the cutting edge being used during the cutting operation. The protective tube is easily removed after a number of deposition cycles and replaced with a new one or, if desired, the tube might be subjected to a cleaning operation such as blasting.

The metallic tube, however, will attenuate the magnetic field. In a preferred embodiment, the thickness of the tube is reduced to less than 1.5 mm, preferably less than 1.0 mm.

The present invention is suitable for automatic loading of the inserts on the tube. In a preferred embodiment the tube is equipped with reinforcement rings, protruding some tenths of a mm from the outer surface of the tube, at intervals along the vertical axis. This is a precaution in order to also allow for a somewhat harsh treatment of the tube during loading and unloading. The objective of the enhancements is to prevent the inserts from slipping down the tube.

In the foregoing description of the invention only very few specific details have been given. The reason hereto is that the exact conditions and optimal dimensions of the details encompassed in the invention will to a certain extent depend on the design of the coating equipment and deposition conditions used. It is within the purview of the skilled artisan to adapt the method of the present invention with regard to the design and deposition conditions used in the specific equipment.

**CLAIMS**

- 5 1. A method of fixturing cutting tool inserts in a PVD (Physical Vapor Deposition) coating equipment characterized in using
- 10 a tube manufactured of a non-magnetic metallic material surrounding a stack of alternating discs of a magnetic material and iron where the north poles of the magnets are directed towards each other and the cutting inserts are positioned on the outer wall of the solid tube and kept in place by the magnetic forces.
- 15 2. A method according to claim 1 characterized in that the cross-section of the tube is circular.
3. A method according to claim 1 characterized in that the thickness of the tube wall is less than 1.5 mm, preferably less than 1.0 mm.

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**ABSTRACT**

5 The present invention relates to a method of fixturing cutting tool inserts in a PVD (Physical Vapor Deposition) coating equipment. The method consists in using a tube manufactured of a non-magnetic metallic material surrounding a stack of alternating discs of a magnetic material and iron. The north poles of the magnets are directed towards each other and the cutting inserts are positioned on the outer wall of the solid tube and kept in place by the magnetic forces.

PVD 01 07 05

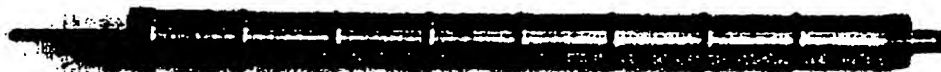


Fig 1.

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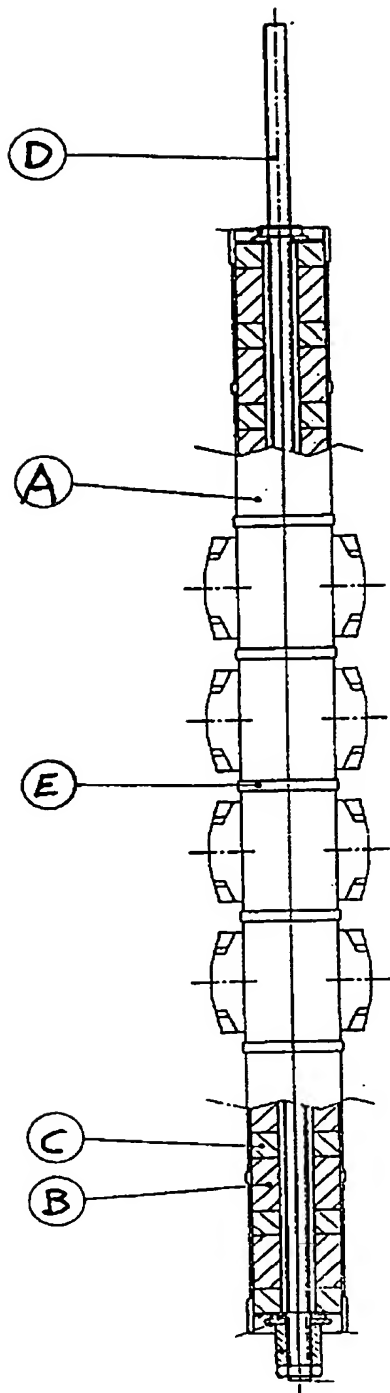


Fig 2

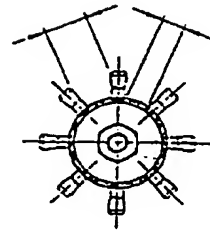


Fig 3

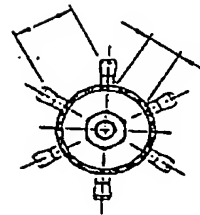


Fig 4